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STUDIES OF IDEA FLOW IN RESEARCH AND DEVELOPMENT*

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ABSTRACT

An Example of field research in organization theory is described--a study of Idea Flow and Project Selection in R & D. A number of previous studies, leading up to the present one are mentioned, indicating the development of the present study. A flow model of the source of projects in an R & D laboratory is presented. A number of research questions are presented, along with the possible sources of theory and some testable propositions. Finally, one major methodological problem is discussed briefly--the real-time measurement of idea flow in operating R & D laboratories.

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26. STUDIES OF IDEA FLOW IN RESEARCH AND DEVELOPMENT*

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THIS IS an example of research in the field of organization theory. It represents a particular view of organization theory and a particular style of research, so that it is not necessarily representative of the increasing amount and diversity of research in this new field.

The viewpoint represented is that of a group of applied scientists—members of the staff and graduate students in our Department of Industrial Engineering and Management Sciences at Northwestern. We view our role in the field of organization theory as that of selecting, refining, and testing theories and notions about organizational behavior. Many of them have been developed or suggested by people in the behavioral sciences who are primarily concerned with theory building per se and who are not necessarily interested in particular organizational contexts. Additional theories and notions have arisen directly out of our own past work or the work of others who are concerned, as we are, with particular organizational contexts.

The particular organizational context that provides the setting for most of our research in organization theory is the Research and Development (R&D) activity. The style of our research involves field studies of operating organizations in their natural settings, but we are not reluctant to attempt building mathematical models of particular aspects of the phenomena or to consider laboratory simulation when it seems appropriate. The purpose of this study is simply stated: it is to increase our understanding of the complex organizational processes which influence the generation, communication, and disposition of ideas for new technical work in an R&D laboratory (12).

Our focus is on the "idea" (Figure 1). We are attempting to study the origins and adventures of (1) ideas or proposals that eventually are accepted and supported as projects by the organization, (2) proposals that are not accepted and supported, and (3) potential proposals which never arrive at a decision point for the organization, but which are disposed of in some other way than outright acceptance or rejection. This latter category, incidentally, entails some difficult conceptual as well as empirical problems. For example, can we properly say that an idea or a proposal "exists" in the organization prior to the time that it is communi-

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cated to someone either formally (such as in seeking official approval and funding for it) or informally (such as mentioning it to a colleague)? Further, if we *can* properly say that it does exist in this precommunication state, how can we gain access to it for purposes of studying its evolution?

The study was initiated in July of 1962. It is being supported by grants from the National Science Foundation and the National Aeronautics and Space Administration, as well as internal fellowship funds.

In this paper, I would like to (1) briefly sketch the historical antecedents of the project, (2) present a highly abbreviated conceptual model of

FIGURE 1

IDEA FLOW IN RESEARCH AND DEVELOPMENT: DEFINITION OF AN "IDEA"

An *actual* or *potential proposal* for undertaking *new technical work* which will require the *commitment* of *significant* organizational *resources* such as: time, money, manpower, energy.

Typically, if accepted, it will result in a *new project:*

Examples:
1. A new method of synthesizing compound X
2. A study of radiation effects on Y
3. An extension of current work on Z into new areas

Not Examples:
1. A suggestion that the company should "go into electronics"
2. A complaint that Product A needs improvement
3. A plan for reorganizing the lab
4. A modification of an experimental setup on an ongoing project

the organizational processes involved in the study, (3) discuss some of the theoretical structure of the study by illustrating some of the propositions which we are considering testing, and (4) discuss one major methodological issue—the real-time measurement of idea flow behavior in organizations.

Historical Antecedents of the Idea Flow Project

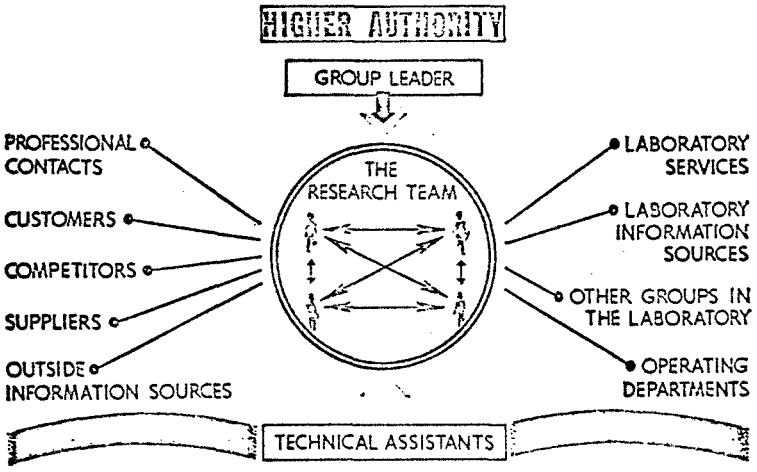
1. *A Study of Team Research* (Columbia University, 1951–53) (7).

We felt that the communication pattern was the key to understanding how a research team or group operates (Figure 2). We made many measurements of the communication behavior of team members, including frequency, direction, participants, and media used.

We realized that we had to know more about the communication events that were being observed and reported. In order to examine the role of communication in the actual work of the research group, we had to have

some indication of the motivation for, the content of, and the consequences of communication events.

We measured one aspect of content and one aspect of consequences. We differentiated between "communication events that were relevent to the project" on which the researcher was working and "other communication events." We also determined, through interview and questionnaire, which events, which individuals, and which communication media had provided "information helpful on the current project."



SOURCE: Industrial Laboratories—October, 1952. (From a paper presented at the Third Annual Conference on Industrial Research, Department of Industrial Engineering, Columbia University, June 9–13, 1952.

FIG. 2. Communication Channels of the Research Team.

2. *A Pilot Study of Sources of Information* (Columbia University, 1953).

This was a follow-up to the Team Research Study, directed toward the motivations for and consequences of "information-seeking" communication events. We asked a sample of researchers to record events in which they sought information from any kind of source—any individual, group, or inanimate reference source. They recorded the problem or question, the source queried, and the answer or result.

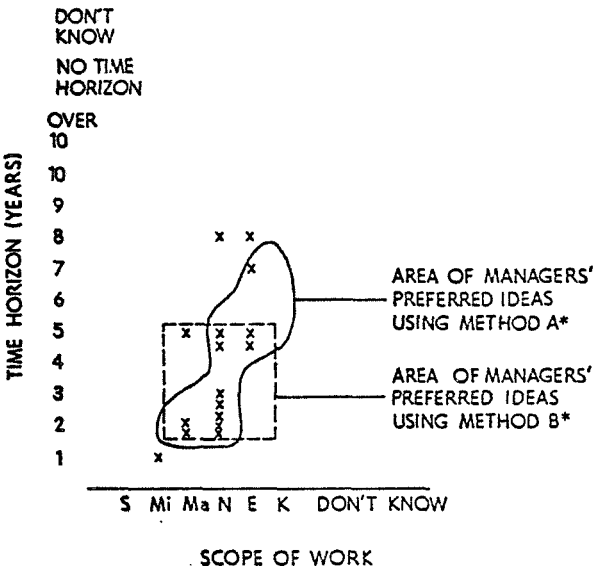
This pilot study was not directly followed up until 1963—ten years later—when a series of discussions began within our group at Northwestern about the possibilities of a large-scale simulation attack on the general problem of "information search" by researchers.

3. *Several Theses and Staff Surveys on Project Selection in R&D* (M.I.T. 1953–59) (16, 5).

Many criteria were collected from the literature and by interview which purportedly were used by R&D managers for evaluating and selecting projects. In addition, many prescribed procedures for proposing

and selecting projects were found. Some came directly from operating organizations, and others were presented by students of the R&D process.

Most of the criteria and procedures encountered in these studies seemed overly formal and rational when compared to actual, observed project selection behavior.



SYMBOLS

S–CUSTOMER SERVICE OR FACTORY SERVICE
Mi–MINOR IMPROVEMENT IN CURRENT PRODUCT OR PROCESS
Ma–MAJOR IMPROVEMENT IN CURRENT PRODUCT OR PROCESS
N–NEW PRODUCT OR PROCESS
E–EXPLORATORY WORK IN FIELDS OF CURRENT OR POTENTIAL INTEREST
K–KNOWLEDGE FOR ITS OWN SAKE

* Two alternative statistical methods.

FIG. 3. Scope and Time Horizon of Managers' Ideas

4. *A Study of the Organization of R&D in Decentralized Companies* (M.I.T. and Northwestern, 1955–64).

This study was an attempt to examine the effects of corporate organizational structure (in particular, administrative decentralization or divisionalization) on the R&D activity within the company. In order to examine such effects, we needed ways of describing the behavior of the people in R&D laboratories.

We concentrated on two aspects of R&D behavior in this study: (1) The actual set of projects being worked on. We established a set of categories for summarizing this into what we called the "project portfolio." (2) Some indication of the kinds of proposals for projects that were

acceptable and not acceptable in the organization. This led us to define an "idea" and attempt to sample the kind of ideas which had recently been and currently were being proposed or communicated in the laboratory.

Here, again, as in the Team Research Study, we were back to studying communication as a key to the operation of an R&D organization—this time at the level of whole laboratories rather than research teams or groups. As part of the study we asked several hundred R&D professionals and managers in a number of laboratories to fill out a detailed questionnaire about ideas in their organization (14). We also conducted follow-up interviews with some of them. Rather than ask them to describe a random selection of ideas, we instructed them to "select the three *best* ideas originated by you during the past year, and the three *best* ideas originated by someone else and transmitted to you (for whatever reason) during the same period."

In contrast to the definition of ideas we are using in the current study—that is, "proposals for new projects"—we employed a more general definition. It included suggestions for "better methods or approaches to ongoing projects" as well as suggestions for "new work that might be undertaken as separate projects."

Analyses of this data, which are still going on, revealed patterns of idea production which could be compared for different hierarchical levels in the laboratory, different levels of education, and other differences between R&D personnel. Figure 3 indicates the approach to categorizing "best" ideas.

This brief historical analysis was intended to indicate the evolution of our present focus on the idea or proposal for R&D work and on certain aspects of the communication process in an R&D activity.

A Flow Model of the Source of Projects in an R&D Laboratory (Figure 4)

Let us conceive of a first approximation to the total list of possible ideas that might be proposed for project status in a particular lab. This is, of course, sheer speculation without a thorough knowledge of the techno-economic environment and capabilities of the organization. That is, in order for an observer to make a reasonably comprehensive list of all of the ideas that *might* be proposed in a given organization at a given time, he would have to know a great deal about the business the company was in, its economic resources, the current state of its technological sophistication, the technical capabilities of its personnel, the states of the various arts that were involved in its field, and so on.

Even with all of this information, however, it still might not be possible for any two experts to agree on a common list. Fortunately, or perhaps as a consequence of this difficulty, the current study design does not require such a list. It does, however, require the *concept* of a feasible list of "Techno-Economic Opportunities" for R&D work by the organization.

This should be a feasible list in the sense that even a casual, if not expert, observer can distinguish between the kind of realistic opportunities that are available to an organization with great technical and economic resources as compared with one that has modest technical and economic resources.

One clue to this feasible list is the behavior of other organizations which are engaged in the same fields as the organization being studied. This notion is being examined in another, separate study where we are attempting to actually establish a rough feasible list for the firms in a particular, narrowly designated market.

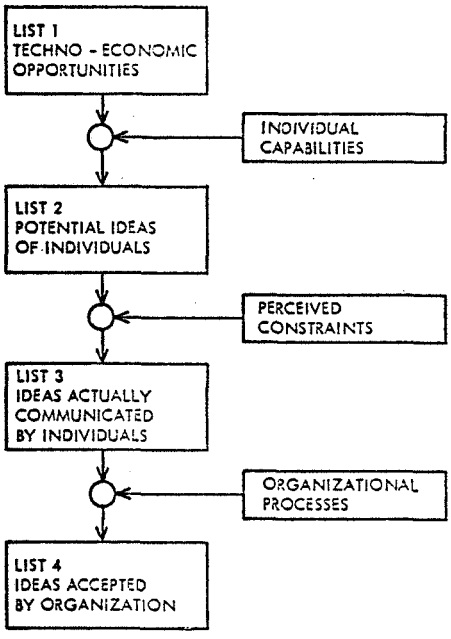


FIG. 4. A Flow Model of the Sources of Ideas or Project Proposals and the Factors Affecting Them

The use to which we want to put the concept of such a feasible list is as a starting point in attempting to define an actual list of potential ideas that might be proposed by the individuals in the R&D organization. That is, the interaction between this total feasible list of techno-economic opportunities for R&D projects and the characteristics of the individual members of the R&D organization generates a second list. This second list might be called the list of all potential ideas that actually might be proposed by the individuals in the organization.

As an illustration of the source of a portion of such a list of potential ideas, consider a new researcher entering an organization. He brings with him certain abilities, formal training, skills, knowledge, interests, and

experience with certain classes of problems. Upon arrival in the laboratory of his new employer, he learns about the businesses the company is in; the nature of its products, production processes, and services; what is currently going on in the laboratory and elsewhere in the company that relates to R&D; what has been tried in the past; and what people are saying and thinking about future possibilities. Through some "mysterious" psychological process—which we variously call creativity, inventiveness, problem solving, serendipity, etc.—he combines some of his abilities and the information he has collected into what might be called an idea for a potential project. He might, depending on his capabilities and the amount of information he has absorbed, have a number of such ideas over a period of time or at any one time. The sum of these individual lists of ideas may be conceived of as the total list of "potential individual ideas" which "exist" in the organization over a period of time or at a particular time.

In the current phase of our work, we have indeed made an attempt to take a total inventory of such potential individual ideas as well as ideas that have already been communicated to others in the organization. We have attempted a complete inventory among all the professionals in four smaller laboratories (Figure 5) and have taken partial inventories in several larger laboratories. Allowing for the many possible errors in obtaining these kind of data directly from subjects, we believe that we have a fair picture, in the four smaller laboratories, of the kinds of ideas that were in existence at the time we took the inventory.

Once we have this second list of potential individual ideas, we consider a third, reduced list. The ideas on this list are the ones that individuals in the organization actually do communicate to others in the laboratory and, in some cases, formally propose for project status.

The reduction in size from the second list to the third list occurs through another "mysterious" psychological process within the mind of the potential proposer of an idea. This process has to do with his perceptions of the possible consequences for him—as an individual, as an employee, as a professional in his field, and in other possible roles—if he does actually communicate his ideas to other people in the organization. Although we do not intend to and are not equipped to probe very deeply into the motivations involved at this stage, we are attempting to get at some aspects. For example, we are attempting to learn how the individual perceives the constraints placed upon R&D work by the various levels of supervision and management. We are also considering ways of evaluating individual risk propensity as a clue to how far an individual will go in testing the limits of such constraints. When list number two—potential individual ideas—is exposed to this set of factors, we can then expect to find a reduced list, number three, which consists of the ideas that the individual actually does communicate to others.

The factors which tend to reduce the third list to the size of a fourth

list—ideas actually accepted by the organization as projects—and in addition, to modify specific ideas on the third list, are the major foci of our study. We call these *organizational processes*. These include, among other things, the communication systems, the power and authority systems, the

Stage	Description of Stage	Number of Ideas Reported, Company Code 1	2	3	4	Total
1	Not yet communicated to anyone	4	8	11	13	36
2	Communicated only informally	24	13	8	28	73
3	Formally submitted but no consideration yet	6	3	3	7	19
4	Being actively considered but no decision yet	23	14	15	13	65
5	Has been rejected	2	1	2	1	6
6	Has been accepted	30	35	22	35	122
7	Other	13	5	10	8	36
	Total Ideas	102	79	71	105	357
	Number of Researchers Responding	29	11	14	14	68
	Ave. No. of Ideas per Researcher	3.52	7.18	5.07	7.50	5.25

*As reported on "Idea Inventory Form" by all professional researchers in four industrial laboratories.

FIG. 5. Stages of Ideas Used in Preliminary Attempts to Inventory Ideas at a Point in Time*

systems of rewards and penalties, and the decision-making systems. Concentration on these organizational processes has strongly influenced the makeup of our group working on the project. It currently includes one full-time sociologist, one sociology graduate student, one consulting sociologist, one consulting social psychologist, as well as four of our own graduate research assistants with training in various branches of engineering, physical science, and business.

The next section of this paper will provide some illustrations of the possible effects of some of these organizational processes on the transformation of list three into list four, including the modification of specific ideas from their original form.

One comment before this, however, may help to clarify our approach to the often tricky notion of the "originator" of an idea. Although the preceding discussion was couched entirely in terms of the individual as the source of the ideas on the various lists, we know that many ideas originate with groups. We make provision for this in our study design and do not attempt to impose the concept of a single individual as the unique originator upon our data and models.

Some Questions and Propositions about Idea Flow

In organization theory, as in other research areas, there are alternative ways of arriving at potentially testable statements which may ultimately lead to explanatory or predictive theories.

One of these has been used by a number of investigators in the field. They have examined or developed a body of speculative, experimental, and/or logically deduced results about organizational behavior. From these results they have extracted or deduced statements about particular aspects of organization, without necessary reference to specific contexts (e.g., production, governmental operations, executive behavior). These statements are then ready for these investigators or others to apply in a particular context.

Another approach involves the extraction of statements directly from observation of specific phenomena in their natural contexts. Then, depending upon the taste and research style of the investigator, there may follow an examination of the literature to see if there are any previous results that support and increase his confidence in the empirically derived statements.

We have used both of these approaches in a number of studies we have been conducting in our program of research-on-research. In the Idea Flow Study, however, we are attempting to use a third approach, which combines some elements of the other two. From our preliminary work on the phenomenon of idea flow, we have extracted a number of questions which appear relevant to an understanding of what is going on. Most of these questions are not initially in testable form. From our knowledge of the literature in organizational theory and the ongoing work of others, we attempt to relate these questions to an existing substructure of theory about organizational behavior. Within this substructure we attempt to derive successively more specific statements or propositions until we reach a level that can be operationalized and subjected to empirical testing within our contextual situation—an operating R&D laboratory.

I will illustrate with several general questions that have resulted directly from the empirical work so far on the Idea Flow Study, and indicate how we might proceed to develop testable propositions with the aid of existing knowledge about more general but related phenomena.

1. Question: What kind of ideas is one likely to find in the project portfolio of a given company?

POSSIBLE SOURCES OF THEORY:
Innovative behavior of organizations (9)
Resistance to change
Learning behavior
Bureaucratic theory

SAMPLE PROPOSITIONS:

1. Organizations with a tradition of heavy dependence on science are likely to have a more diversified portfolio of projects in terms of time horizon (estimated time to completion) and scope (relation to current products and processes) than organizations lacking such a tradition. Figure 6 presents some empirical evidence related to this proposition, in terms of "time horizon."

2. Organizations with a history of successful results from R&D are likely to include riskier projects in their portfolios than ones without such a history.

Period in Which Work Started

and Number of Projects

Estimated Time to Complete - Months	Year Work Started → / Month or Period →	Prior to July 1960	1960 7-12	1961 1-6	1961 7-12	1962* 1,2	Row Total
	0 - 3	0	2	1	9	3	15
	4 - 6	4	5	5	3	3	20
	7 - 9	1	1	5	6	4	17
	10 - 12	7	2	2	2	1	14
	13 - 18	3	6	2	5		16
	19 - 24	6	5	1			12
	25 - 30	7					7
	31 - 36	1		2			3
	over 36	12	1	1	1		15
	Totals	41	22	19	26	11	119

median for data from approximately a five year span

*Note: 1962 = 1st 2 months only

•——• = Median classification over time

FIG. 6. Company 20. Distribution of projects by estimated time to complete versus period in which work started.

	Project Management Department*						
	Person Contacted	Q 6 Consulted Freq	%	Q 7 Convinced Freq	%	Q 9 Originated Freq	%
1	In Dept.	31	55.3	27	67.8	28	59.5
2	Not R and D/In the same Branch	2	3.6	1	2.3	2	4.3
3	Other Branches	6	10.7	3	7.0	1	2.1
4	Customer	3	5.4	0		4	8.5
5	Vendor	0	0	0			
6	Tech. literature	0	0	0			
7	Consultant	0	0	0			
8	Other R and D Depts.	14	25.0	12	27.9	12	25.5
	Totals	56	100	43	100	47	100
	Reliability Department †						
	Person Contacted	Q 6 Freq	%	Q 7 Freq	%	Q 9 Freq	%
1	In Dept.	62	62	50	61.7	40	64.5
2	Not R and D/In the same Branch	11	11	10	12.3	2	3.2
3	Other Branches	3	3	6	7.4	1	1.6
4	Customer	3	3	2	2.5	6	9.7
5	Vendor	1	1	0	0		
6	Tech. literature	1	1	0	0	1	1.6
7	Consultant	1	1	0	0		
8	Other R and D Depts.	18	18	13	16.0	12	19.4
		100	100	81	100	62	100

Q 6 = Who was consulted about your ideas
Q 7 = Whom did you try and convince about your ideas
Q 9 = Who was the originator of others' ideas

* Men in Dept.: 49; Men Reporting: 31; % Reporting: 63.3%
† Men in Dept.: 54; Men Reporting: 33; % Reporting: 61.1%.

FIG. 7. Consultation Patterns—Number of Mentions

II. QUESTION: To whom is an idea originator most likely to communicate for purposes of seeking advice on his ideas or attempting to convince people of the merits of his ideas?

POSSIBLE SOURCES OF THEORY:

Sociometric patterns in professional organizations (3, 8)
Bureaucratic theory
Small group theory

SAMPLE PROPOSITIONS:

1. Researchers are most likely to consult initially with their peers about their own ideas.

2. Intragroup communication will be greater than cross-group communication in a highly structured organization. Figure 7 presents some data on this, from a very large organization (15).

3. At least one liaison person who can transmit ideas outside the group will be found in each "successful" laboratory group.

III. QUESTION: To whom is an idea originator (O) most likely to; (a) first communicate his idea and (b) ultimately propose it for consideration by the organization?

POSSIBLE SOURCE OF THEORY:

Superior-subordinate relations in work groups (11)

SAMPLE PROPOSITIONS:

1. If O's superior (S) shares O's orientation and has influence with his (S's) superiors at the next level, O will more likely propose his ideas to S than if these conditions did not hold. Some data on the sharing of orientations toward ideas is presented in Figure 8.

2. If S does share O's orientation, but is not perceived by O as having influence with S's superiors, O will seek other channels for proposing his ideas.

IV. QUESTION: What kind of criteria will an individual use in deciding whether to actually propose an idea?

POSSIBLE SOURCES OF THEORY:

Subjective probability
Personality theory
Role theory
Professional orientation (6)

SAMPLE PROPOSITIONS:

A researcher with high "organizational" and low "professional" orientations will tend to propose ideas more closely related to the current, obvious needs of the organization than will a researcher with high professional orientation and either high or low organizational orientation. This relationship is illustrated below:

EFFECT OF ORIENTATION ON IDEAS

		ORGANIZATIONAL ORIENTATION	
		Low	High
PROFESSIONAL ORIENTATION	Low		closest
	High	less close	less close

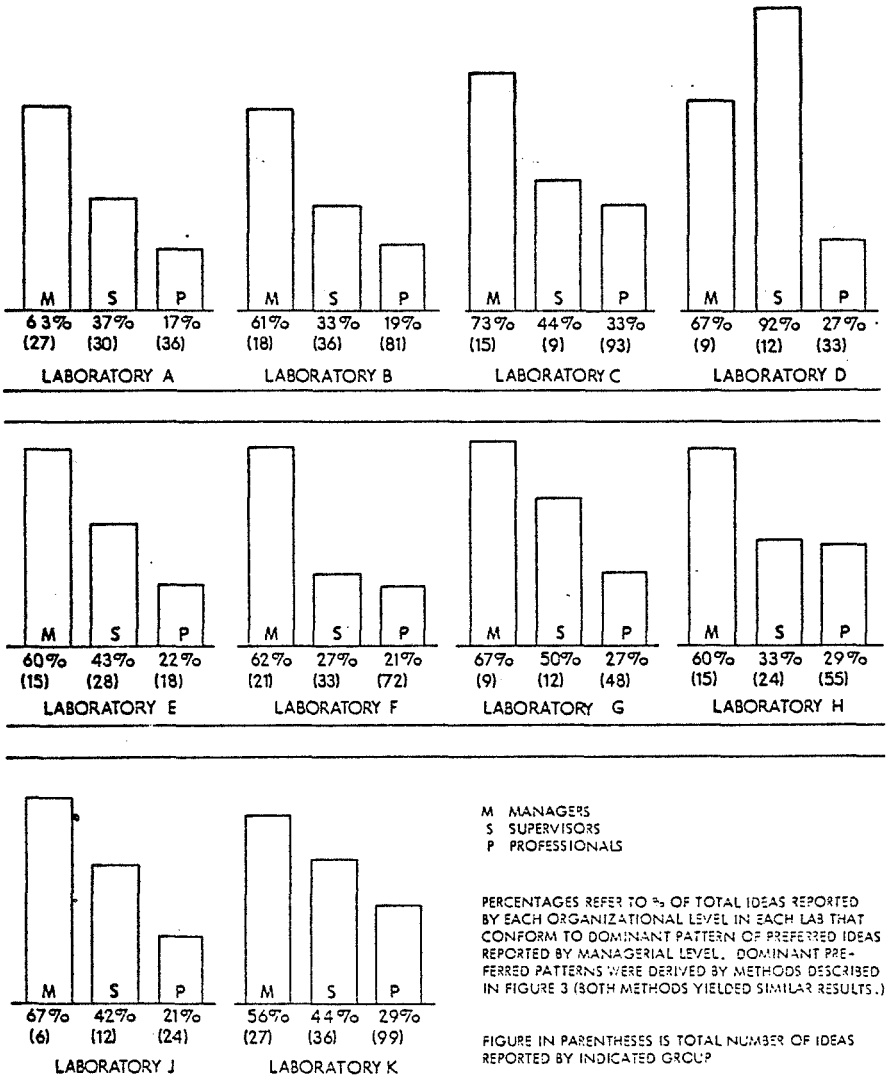


FIG. 8. Patterns of Idea Production: Managers, Supervisors, and Professionals

V. QUESTION: How do patterns of ideas emerge in a laboratory over time?

POSSIBLE SOURCES OF THEORY:

Organizational growth (18, 17, 1)
Theories of enculturation (2)
Learning theories

SAMPLE PROPOSITIONS:

1. R&D groups in a "low-science" environment which are established with a "high-science" charter will tend to drift into proposing ideas of a lower scientific level over time, unless the charter is continuously reinforced.

2. Reinforcement can occur through combinations of the following kinds of mechanisms:

a) An early, widely recognized success

b) An independent source of funds (independent from clients with immediate, low-science problems)
c) Adequate insulation from outside pressures
d) An internal, *real* (as contrasted with mere honorific) reward system

VI. QUESTION: What are the effects of rejection of O's ideas on the likelihood of additional ideas being proposed by O?

POSSIBLE SOURCE OF THEORY:
Theories of cognitive dissonance
SAMPLE PROPOSITION:
If O can successfully rationalize to himself the rejection of his past ideas by the organization, he will continue to propose additional ideas.

Real-Time Measurement of Idea Flow in Research and Development

One of the major methodological problems that field researchers encounter when studying real operating organizations is the temporal distortion of data.

This distortion is the result of a number of factors, and we have encountered various combinations of them in our field studies of R&D organizations over the past dozen years. Some of the principal factors leading to distortion in the current series of field studies on the idea flow are these:

Difficulties in recall of events and the surrounding circumstances by subjects, in response to interviews and questionnaires.

Post hoc rationalization of the way the subject would have liked the events to have occurred.

Distortion of (1) sequence of events and (2) spacing of events.

Loss of the emotional color that accompanied the actual event, e.g., attitudes and interpersonal relations at the time of the event.

Simultaneity of surrounding events and circumstances that might help to explain or bring into better focus the actual event.

Although we encountered problems of this type in our first series of field studies of R&D laboratories—the Team Research Study (13)—the nature of the events we were collecting enabled us to handle the problem in a fairly simple manner. We were merely interested in communication events and wanted a minimum of information about them, such as the participants, the time they occurred, and their relevance to the subject's current project. The "density" of these events—the number per unit time—was sufficiently high and the uniformity was also sufficiently high to permit the use of random sampling techniques.

In contrast, as indicated by Figure 9, the density of "idea-related events" is much lower. Furthermore, these events are much less uniform with respect to the variables we are examining.

In addition, there are questions of economy and "reactivity"—adverse effects on the subjects and deterioration of the subject-investigator relationship. As we have found so far, the typical frequency of idea-related

events is something less than one per day (in some cases it is much less—as little as one per week or month for a given subject). We therefore encounter severe problems of economy and reactivity when we attempt to use standard (or modified) time sampling techniques, as we did in the Team Research Study. In that study, we "appeared" in each laboratory one or more times per day and, because of the nature of the phenomena we were investigating, we struck pay dirt almost every time. That is, we did indeed find the subjects engaged in a communication event almost every time we made a visit. This helped us to justify the visit on economic grounds and also appeared to provide some satisfaction—or at least lack of annoyance—for the subject.

FIGURE 9

RELATIVE DENSITY OF VARIOUS LEVELS OF COMMUNICATION EVENTS

Level	Estimate of Frequency
Total communication events*	16 per man day
Information-bearing events*	10 per man day
Idea-related events†	Less than 1 per man day

* SOURCE: Team Research Study (1952)
† SOURCE: Rough estimate based on preliminary field interviews in Idea Flow Study (1963)

In one of the idea flow field studies, on the other hand, we experienced severe diseconomies, plus a near-fatal reaction by the subjects who were tired of being asked what had happened on "idea X" when nothing had happened since the last time (4).

We are still working on this problem and have tried a variety of approaches, including a self-administered instrument and a "remote control" instrument (10).

Summary

An example of field research in organization theory was described—a study of Idea Flow and Project Selection in R&D. A number of previous studies leading up to the present one were mentioned, indicating the development of the present study. A flow model of the source of projects in an R&D laboratory was presented. A number of research questions were presented, along with the possible sources of theory and some testable propositions. Finally, one major methodological problem was discussed briefly—the real-time measurement of idea flow in operating R&D laboratories.

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